Control of *Lymantria dispar* L. by biological agents

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Abstract: The experiment on control of *Lymantria dispar* L by using different kinds of biological measures, including nuclear polyhedrosis virus (NPV) of *Lymantria dispar* L., BtMP-342, sex-attractant as well as botanical insecticide, was carried out in the forest regions of Inner Mongolia in 2003. Two concentrations (2.632×10^6 PIB · ml^{-1} and 2.632×10^7 PIB · ml^{-1}) of *Lymantria dispar* L. NPV were sprayed on the 2rd-instar-larvae of *L. dispar* and 70% and 77.8% control effect were obtained respectively. BtMP0-342 was applied to the 3rd- and 4th-instar larvae and the control effect was around 80%. The sex-attractant provided by Canada Pacific Forestry Research Center also showed a good result in trapping *L. dispar* adults. The self-produced botanical insecticide, which was extracted from a kind of poisonous plant distributed in Daxing'an Mountains, China, exhibited a good control result in controlling the larvae of *L. dispar*, and 82% mortality was observed when spraying primary liquid of the botanical insecticide on the 3rd–5th-instar-larvae in lab.

Keywords: *Lymantria dispar* L.; Biological agent; Biological control
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Introduction

Lymantria dispar L. is a worldwide leaf-eating pest (Savotikov *et al.* 1995; Yang 1996; Davidson *et al.* 1999), with wide distribution and feeding source, and many host plants. This pest can injure many species of conifer, broad-leaf, as well as some fruit tree species, and the destructive result is rather serious (Lin *et al.* 2000; Lin *et al* 2002). In recent years, *Lymantria dispar.* is very epidemic in the regions of Daxing'an Mountain in Inner Mongolia, and the outbreak area has reached to about 70 000 hm^2. The control of *Lymantria dispar* mainly adopted chemical insecticides in the past (Zhang *et al* 2001). Though chemical control measures can reduce the insect population quickly in a short time, at the same time, it can also lead to environmental pollution, cause death of its natural enemies, and result in mass-outbreak of pest again. As chemical control measures have many disadvantages in practice, its application is restricted in varying degree. Consequently, biological control measures has been developed gradually (Lewis *et al.* 1982; Farrar *et al.* 1995). Biological controls mainly adopt bacteria (Knowles *et al.* 1994; Shen *et al.* 1994; Liu *et al* 1999), viruses (Bergold 1963; Xu *et al* 1979; Granados 1980; Charton *et al.* 1999), and pheromone to control the pest. Biological control has many advantages on controlling pest. However, up to now it has not been used widely in a larger area of production control (Yue *et al.* 1984; Ding *et al.* 1993; Zhao 1996).

In this study several kinds of biotic insecticides were practicably used to control *Lymantria dispar* in large area. The experimental results can provide scientific foundation for controlling the population density of *Lymantria dispar* as well as forecast of the pest.

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Materials and methods

Nuclear polyhedrosis virus (NPV) of *Lymantria dispar*

The dead larvae of *Lymantria dispar* L. infected by NPV of *Lymantria dispar* L. were collected, and then NPV was purified by centrifugation. The living larvae of *Lymantria dispar* were fed by natural or artificial fodder. When the larvae developed to the fourth-instar, they were inoculated by NPV for breeding *Lymantria dispar* NPV. The NPV was kept in refrigerator for field use.

Lymantria dispar L. NPV is a kind of organism with bioactivities. For compounding the NPV insecticide, some auxiliary agents need to be added in order to fully bring into playing the effects. The activated carbon and berberine were used as sun protective agent. $CuSO_4$ as a synergist, neutral washing powder as adjuvant, Tuwen-80 as emulsifier, and $CaCO_3$ and Kaolin were used as filling agent.

Bt MP-342 bacterial agent

Bt-MP342 bacterial agent was provided by Hubei Bt Research and Produce Center at Wuhan, Hubei Province, and the consistency is 30 000 IU · mg^{-1}.

In 2003, spraying test of Bt MP-342 ware carried out on the third-instar and fourth-instar larvae of *Lymantria dispar* at De'erbu'er and Genghe Forestry Bureaus, Inner Mongolia, by ground spray with stretcher atomizer. After spaying the effects of insecticide were investigated with cages and the control area was set to calculate the corrected mortality of the insect.

Trapping

The sex-attractant was an artificial synthetic product which was from Canada Pacific Forestry Research Center (PFC). Three kinds of traps (Fig.1), such as jar plastic trap, barrel trap, and hard paper reef container, which were also provided by Canada PFC, were used in the experiment.

The trapping experiment of *Lymantria dispar* adult was conducted in natural larch forest at Xiao'anjin Forest Management Site of Kuyagou Forest Farm, Tulihe Forestry Bureau, Inner Mongolia during July and August of 2003. Fifteen groups (3 kinds of traps for each group) of traps with sex-attractant were

placed, at a height of 1.5 meters above the ground, per hectare.

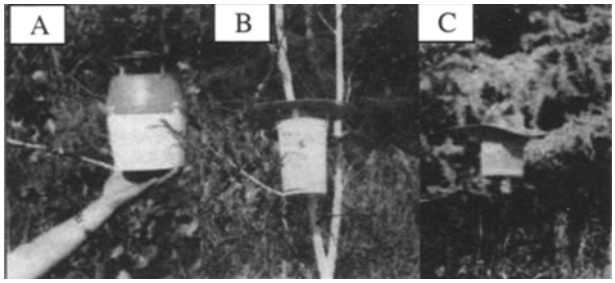

Fig. 1 Three kinds of traps used in traping *Lymantria dispar* adult

A: Jar plastic trap; B: Barrel trap; C: Hard paper reef container

Botanical insecticide

In the middle of May of 2003, a whole piece of wild celery was collected in the woodland of Tahe Forestry Bureau, Heilongjiang Province. The sample was washed clean, and then weighed 500 g and cut it into small pieces, added 1-L water, triturated for five minutes, then filtered. And the filtrate is plant insecticide. Before using, the botanical insecticide need to be well shaken, then it was diluted to the different concentrations. Atomizer was used for spraying, and the effects of contacting poison and stomach toxicity were determined.

Results

Application of *Lymantria dispar* L. NPV in the woodland

The second-instar larva of *Lymantria dispar* was controlled with *Lymantria dispar* L. NPV produced in the same year. The NPV viral pesticide was diluted with two concentrations of 2.632×10^6 PIB · ml^{-1} and 2.632×10^7 PIB · ml^{-1} dilution, and sprayed in the sample sites. The mortality of the larva of *Lymantria dispar.* was investigated. The average corrected mortality after 22 days was 70.39% for 2.632×10^6 PIB · ml^{-1} viral pesticide and 77.8% for 2.632×10^7 PIB · ml^{-1} viral pesticide (Table 1).

Table 1. Controlling results of the second-instar larva of *Lymantria dispar* L. by using *Lymantria dispar* L. NPV

NPV concentrations (PIB · ml^{-1})	Repeat	Number of insect (Head)	Number of death (Head)	Mortality (%)	Average corrected mortality (%)
2.632×10^6	1	78	59	75.64	70.39
	2	56	42	75.00	
	3	72	51	70.82	
2.632×10^7	1	87	73	83.91	77.80
	2	84	67	79.76	
	3	118	91	77.12	
Control		63	7	11.11	

Controlling the larva of *Lymantria dispar* by Bt MP-342 bacterial agent

The third-instar and fourth-instar larva of *Lymantria dispar* L. at two forest farms of De'erbu'er Forestry Bureau, Inner Mongolia were controlled by ground spraying of 500-times Bt MP-342 bacterial agent, with a total control area of 3.33 hm^2, and more than 80% corrected mortality was obtained (Tables 2). Meanwhile, the same experiment was conducted at Genhe Forestry Bureau, Inner Mongolia, with a control area of 4 hm^2, and the corrected mortality reached 89.7% (Table 2)

Table 2. The control results of the larvae of *Lymantria dispar* by using BtMP-342 bacterial agent

Experimental sites	Plot No.	Number of insect per group (Head)	Died insect (Head)	Mortality (%)	Average mortality (%)	Average corrected mortality (%)
At 23 routine in De'erbu'er Forestry Bureau, Inner Mongolia	1	30	23	76.7	81.3	80.0
	2	30	27	90.0		
	3	30	24	80.0		
	4	30	23	76.7		
	5	30	25	83.3		
	Control	30	2	6.7		
At 60 routine in De'erbu'er Forestry Bureau, Inner Mongolia	1	30	24	80.0	80.7	79.3
	2	30	23	76.7		
	3	30	25	83.3		
	4	30	27	90.0		
	5	30	22	73.3		
	control	30	2	6.6		
At 27 routine in Jiaodaomu Forest Farm, Ganhe Forestry Bureau, Inner Mongolia	1	30	28	93.3	90.7	89.7
	2	30	26	86.7		
	3	30	27	90.0		
	4	30	27	90.0		
	5	30	28	93.3		
	Control	30	3	10.0		

Controlling *Lymantria dispar* adults by sex-attractant

In 1930s, the research on sex-attractant of *Lymantria dispar* L. started as early as the 1930s. Until the 1970s, the sex-attractant had been synthesized artificially and used in forecast and trapping of *Lymantria dispar* adults successfully. Recent years, the sex-attractant of *Lymantria dispar* has already been applied to the integrated control of the pest.

In this study, experiment on trapping the adults of *Lymantria dispar* by the sex-attractant of *Lymantria dispar* was conducted at Tulihe Forestry Bureau, Inner Mongolia. Totally, 450 adults were trapped in the average per group of traps from 20th to 30th of July, 2003, at the same time, 136 *Lymantria monacha* L adults were also trapped.

Controlling *Lymantria dispar* larva by botanical insecticide

The self-produced plant insecticide was sprayed on the 3rd,- 4th-, and 5th-instar larvae of *Lymantria dispar* in Lab, and the results were shown in Table 3.

Table 3. The statistics of controlling the larva of *Lymantria dispar* L. by plant insecticide

Diluted times	Quantity of *Lymantria dispar* L. /Head	The death quantity /Head					Mortality (%)	Modified mortality (%)
		12h	24h	48h	72h	Total		
Original liquid	200	85	52	15	13	165	82.5	82.2
6	200	43	27	12	9	91	45.5	44.9
10	200	34	23	8	9	74	37.0	36.4
20	200	31	12	10	6	59	29.5	28.8
40	200	18	6	7	5	36	18.0	17.2
80	200	4	5	0	1	10	5.0	4.0
Contrast	200	0	0	1	1	2	1.0	

Conclusion and discussion

Effects of *Lymantria dispar* L. NPV on controlling *Lymantria dispar* larvae

Lymantria dispar L. NPV, as a very important measure of biological control, plays a key role in controlling *Lymantria dispar* L.. For reproduction of NPV on larvae of *Lymantria dispar,* both natural and artificial fodders can also meet the demands of growth and development of *Lymantria dispar* larvae. The cost of natural fodder is lower than that of artificial fodder, but it is apt to limit by season. Artificial fodder is helpful to controlling the other bacterial pollution in reproducing NPV. Since *Lymantria dispar* L. NPV is likely to lose activity in directly exposing to the sun, some sun-protective agent need to be added in compounding NPV insecticide. Our experiment on control of the larvae of *Lymantria dispar* L. in woodland showed that *Lymantria dispar* L NPV with concentration of 2.632×10^{7} PIB · ml^{-1} had a good control effect (77.89% mortality), which can easily cause epidemic of the NPV in *Lymantria dispar* larva population so as to reach an aim of long-term control.

Effect of Bt on controlling *Lymantria dispar*

Bt, the most abundant microbiological insecticide in yield in the world, has been developed and utilized comprehensively in recent years, and many new sub-species and bacteria strains were produced in succession. BtMP-342, with a concentration of 30 000 IU · mg^{-1}, produced by Hubei Bt Development Center, has good properties of biotic insecticide. Our experiment showed that diluted 500-times BtMP-342 had the control effect of *Lymantria dispar* larva ranged from 80% to 90%.

Effect of sex-attractant on controlling *Lymantria dispar*

Trapping *Lymantria dispar* adults by using sex-attractant of *Lymantria dispar* L. can be regarded as one of important methods in forecast and biological control, with some advantages of no pollution to the environment and no harm to natural enemy. The traps and sex-attractant used in this experiment were provided by Canada Pacific Forestry Research Center. The result indicated that the core of sex-attractant can be used as long as 20 days. Jar plastic trap and barrel trap can be used for a long time. The hard paper reef trap is cheaper, convenient, but not permanent in use.

Effect of botanical insecticide on controlling *Lymantria dispar*

The research advance of plant insecticide is very rapid and has achieved many important achievements. In this experiment, the self-produced botanical insecticide was extracted from a kind of poisonous plant. The larvae of *Lymantria dispar* were killed by using primary liquid of the botanical insecticide, with a corrected mortality of 82%. This botanical insecticide is a harmless biological insecticide and has a widely developing and applying foreground.

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